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DESIGN OF ELECTRICAL DISTRIBUTION NETWORK FOR 1000 HOUSING UNIT

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ABSTRACT
This paper deals with the design of electrical distribution network for 1000 housing units Kano road, Maiduguri, Borno State. The distribution system is designated to be overhead line, because it is cheap and tapping can be conveniently made at anytime. The overhead line accessories such as the pole, conductors, insulators, cross arms stay insulators and stay wives are also designed to suit the area. The transformer ratings are design to be ten number of 500 KVA (11/415V). The system is also designed to carry the load imposed upon it without damage to the conductors. The system can also meet the load variations which are likely to arise in near future and provide continuity of supply.

INTRODUCTION
Electricity is the most convenient and useful form of energy. Without it the present social infrastructure cannot be feasible. The increasing per capital consumption of electricity throughout the world reflects a growing standard of living of people (A.S Pablo 2000) and the optimum utilization by society of this form of energy can be ensured by effective supply and distribution system. Distribution system differs from transmission system in several ways. Apart from voltage magnitude, the number of branches and source is much higher in distribution system and the general structure topology is different. Transmission is normality implied, the bulk transfers of power by high voltage between main load centers. Distribution on the other hand is, mainly concerned with the conveyance of power of consumer by means of lower voltage network. Due to expansion in the use of electricity, the demand on the distribution become greater and more complex. Therefore, the distribution network are designed to bne able to carry the load imposed upon it without causing excessive heating in the consumers conductor and consequent damages to the insulator. The voltage drop through the network must be kept to minimum so as to maintain the voltage at the customer terminal within specified units (i.e. 6% of the nominal value) whatever the loading conditions (NEPA electricity distribution manual 1977).

METHODOLOGY
This chapter deals with how the electrical distribution network for 1000 housing unit was designed; the distribution network was also designed to be overhead type which technically suits the area. The type of line support and their accessories are also designed to the technical standard. Distribution substation is also designed to receive energy from a higher voltage system, convert into a form suitable for local distribution.

LINE SUPPORTS

For the purpose of this project, a steel reinforced concrete pole was designed, the poles were designed to be 8.5m length for the low voltages and 10m length for the high voltage line. The span length for the low voltage lines was designed to be 40m while that of high voltage line was designed to be 50m, this is to avoid the difficulties of terrains, urban development and natural hazards. The reinforced concrete pole have the advantage of longer life, shattering tendency when hit by vehicles and can be used in areas that have high humidity.

ACCESSORIES OF OVERHEAD LINES DESIGNED FOR THESE PROJECT ARE:

i. CROSS-ARM

A hot dip galvanized cross-arms are designed for the project, the length of the cross – arm should be 1.63m long and, the bolts and nuts of 5mc and 8mc respectively should be used.

The hot dip galvanized has the following advantages:

a. It has longer life.
b. They cannot be attack by termites
c. They are stronger than the wood types.

ii. INSULATORS

For the insulation of the distribution lines, use shall be made of porcelain insulators as specified in B.S. 137. The Disc type insulator of approximately 254mm in diameter, 6.3kg in weight and mechanical failing load of 10.6KN should be used for the high voltage lines. Also for the low – voltages a single groove type shackle insulator of 76mm in diameter, 0.4kg in weight with a mechanical failing land of 19KN should be used.

iii. CONDUCTORS

Conductors used are aluminum conductors (AAC), conductors shall be 50mm^2 and 100mm^2 in size for the high voltage and the low voltage respectively. Base conductors shall be used in normal conditions, conductors shall be hard drawn aluminum twisted wires made of aluminum for electric purposes. However, it major advantage is that it is cheaper than copper.

DESIGN OF DISTRIBUTION TRANSFORMER

The total load demand of the whole housing units have already been designed by Ministry of Works and Housing Borno State. The total load was used to determine the actual size of the transformer required for the area.

TRANSFORMER LOCATION AND ITS LOADING CONDITION

Distribution transformers are output rated, then can deliver their rated KVA without exceeding temperature rise limits when following condition are applied (ABB,1995).

a. The secondary voltage should not exceed 105% of rating.
b. The load factor should be >80%.
c. The frequency should be > 95% of rating.

Transformers are to be located at the centre of load so as to minimized the looses and maintaining quality supply to a consumer.

Each transformer is designed to carry 440.0184 KVA, Therefore it should be placed at the load centre even though the loads are not evenly distributed.

SUBSTATION

1. **TRANSFORMER**

A step-down transformer of ground mounted outdoor type was designed. The high voltage sides and low voltage sides of the transformer shall be fitted with cables boxes in accordance to B.S 2562 part equipment. They shall allow connection of 50mm2 paper insulated copper cables on high voltage side and 50mm2 PVC Insulated copper cables on low voltage side. The Cable size was designed considering the rating of the transformer. According to IEE regulation 7m, 50mm2 copper cable should be connected on the high voltage side and 15mm2 copper cables should connected on the low voltage side.

ii. **LIGHTING ARRESTERS**

For each transformer, there lighting arresters shall be installed in order to protect the system from high voltage surge due to lighting. They should be attached to the high voltage side of this transformer and this arrangement will send any over voltage which falls on the system due to lighting to the ground directly.

iii. **DROPOUT FUSES**

The dropout fuses shall be of cross arm mounted type with such construction as shall allow opening and closing operation of the contact safely by an operating rod. Its construction shall be such that after this operation of the fuses shall construct as shall allow opening and closing operating of the contract safely by an operating after the operation of the fuses, the primary and secondary will be disconnected from each other and complete insulation will be maintained. Fuses intended for the dropout fuse switch shall be mounted on the switch and shall meet the rating capacity of 1200MVA in the case of short circuit failing on the transformers side.

iv. **EARTHING**

According to (Anthony J., 2006), the neutral conductors of low voltage shall be earthed at the supply point and each and every terminal as well as at interval of 250m along the distribution line route. The ear thing shall be covered copper conductor and it cross-section shall be less than 25mm earthling rods shall be used to served as earthling electrode, each ear thing rod2.5cm in diameter and 1.8m in length.

ii. FEEDER PILAR REQUIRED FOR THE LOW VOLTAGE LINE

Four feeders shall be provided for the four voltage line. The feeder pillars should be water proved and installed. Each pillar should contain.

i. 3-fuse set, 3-phased and a neutral for overhead line feeders
ii. 1-fuses set, 3-phases and a neutral for input cable from transformers.

According to (Grigsby L.L. 2001), the incoming and outgoing cable should allow connection TO 150MM copper cables on the transformer side and 70mm copper cable on the side feeder side. Therefore, each transformer shall be provided with feeder pillar.

CONSTRUCTION OF SUBSTATION

According to (NEPA Manual, 1977), the foundation which the transformer is to be installed be composed of an upper concrete base 20 to 25cm in thickness and wider than the transformer bottom by 10cm, reinforced by the steel wire 10mm in diameter placed cross-wise at a depth of 5mm below the surface. A lower concrete base wider than the upper one by 10cm shall be constructed, there under a layer of stones of 150 to 200mm in diameter, 30cm thickness shall also be placed.

Substation shall be constructed away from any such places:-

i. Along heavy traffic road where motor cars are likely to collide.
ii. Where the soil is soft.
iii. Where people are frequent
iv). As is likely to be flooded.

PROTECTION REQUIREMENT

i). According to IE.E. Regulation A8 –A10, Every consumers installation supplied from a external source shall be adequately controlled by protection equipment accessible to consumer, the protection equipment should incorporate:
i. Means of Isolation
ii. Means of excess current protection.

Circuit breakers was designed for the protection of excess current every conductor in the installation is to be protected by a circuit breakers fitted at the origin of the circuit. The current rating of the circuit breaker should not exceed the current rating of the lowest rated conducted in the protected circuit.

ii) Earthling: According to IEE Regulation D1, every conductor shall be prevented from giving rise to earth leakage current by earthling of exposed metal parts.

For this purpose of the project, it was designed that all conductor are earth to ground suing earth electrode.

RESULT & DISCUSSION

Based on the design of this project, the following results were obtained.

TABLE 1:5: RESULT FOR OVERHEAD LINE DESIGN

S/N	ITEM	TYPE	SPECIFICATION
1	Line support	Concrete poles	10m long – H.T 8.5m long –L.T.
2	Cross-Arm	Hot-Dip Galvanized Cross-arm	1.63m long
3	Insulator	Disc Insulator Shackle Insulator	254mm diam. 76mm diam.
4	Conductor	AAC	50mm – H.T 100mm – L.T.

the total load demand for the whole unit will be the total maximum demand of all loads centers. Therefore the grand total = 11220. 47kw.

Now, power = 3V1 cosØ, where Ø is the power face for and it is taken as 0.85.
Therefore, IV = $\frac{\text{total power in kw}}{3Ø}$

$$VI = \frac{112220.47}{3 \times 0.85} = 4400.184kw$$

Where VI, is the KVA which determines this size of transformer to be used. The total KVA = 4400. 184KW, now it is designed to use10X 500KVA transformers.

TABLE 1:6: MAXIMUM LOAD DEMAND FOR WHOLE UNIT.

S/N	BEDROOM FLAT/OTHER	TOTAL LOAD DEMAND (KW)
1.	Four Bedrooms	176. 9
2.	Three Bedrooms	1944.4
3.	Two Bedrooms	6192.4
4.	One Bedroom	1100
5.	Primary School	7.5
6.	Boreholes	180
7.	Street Light	1.5
8.	Fire services	2.5
9.	Transformer designed	10 x 500KVA

From table 1.5 above, it can be seen that concrete poles were designed for the project; wooden poles are rather short in service life because they are unapplicable in place that have higher humidity and liable to be affected by insects or animals. It can be conducted that concrete poles have advantage over wooden poles. Although pin type insulators are also available but because of it low level of insulation, disc type was used as specified by B.S 137 All aluminum conductors of 50mm were designed for the high voltage line while 100mm was designed for the low voltage line. Aluminum was used because of it cheaperness and easy to machine. Standard cross-arms shall have a size of either 1.63 or 2.24m. For places that require span length size cross –arm will be used, but for the purpose of this project which the span length is not more than 80m, 1.63 size was designed. The total load demand for each unit was calculated in table 1.6 above. This load demand was added to have maximum load demand for the whole unit. The transformers designed for the whole unit was obtained by considering this maximum load demand of the area. It can be concluded that ten number of 500KVA transformers was designed for the purpose of this project.

BILL OF ENGINEERING MEASUREMENT AND EVALUATION FOR THE OVERHEAD LINE DESIGN

S/N	ITEMS	QUANTITY	UNIT COST (N)	TOTAL COST (N)
1	H.T Poles	80	28,000	224,000
2.	100m conductor	70,000mt	150.00/mtr	10,500,000
3.	11 KV Insulator	220	2,000	440,000
4.	11 KV cross arm	80	4,500	360,000
5.	50mm conductor	4,000	115.00/mtr	460,000
6.	D-Iron complete	1,600	500	800,000
7.	L.T poles	440	21,000	9,240,000
8.	L.T stay assembly	500	4,000	2,400,000
9.	4-way feeder piller	10	120,000	1,200,000
10.	Lighting Arrester	30	18,000	540,000
11.	D- fuse	30	18,000	540,000
12.	Substation Civil Work	10	9,000	90,000
13.	500 KVA transformer	10	750,000	7,500,000
14.	Labour	-	-	2,000,000
15.	VAT (10%)	-	-	3,831,000
16.	**Grand total**	-	-	**42,141,000**

CONCLUSION

The objective of the design is to provide electrical power supply to the newly completed 1000 housing units because the optimum utilization by society of electrical energy can be ensured by effective supply and distribution system. Also, electricity is the most convenient and useful from of energy, without it the present social infrastructure cannot be feasible, hence there is a need to electrify the area. The designed network of the area can carry the load imposed upon it without excessive heating in the conductor and consequently damages to the insulation. The voltage at the consumer terminal is kept within the specified limit (i.e. 6% of the nominal value). (NEPA Manual,1975). The system as designed can meet the load variations which are likely to arise in near future and provide continuity of supply and should a fault occur on the system, interruption in the supply to the consumer should last for a shortest possible time. The system is very simple to maintain and operate and routine maintenance should be carried out with minimum interruption to power supply. From the above results, it can conclude that the system is quite reliable. Since the reliability of any good designed system depends on efficient control equipment such as circuit breakers, lighting arresters, fuses etc, hence it is necessary to incorporate in this design to obtain reliable system. The overhead lines distribution and the electrical installation designed for this project will suite the area, because it is cheaper and easy to maintain.

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